Chapter 7

Railway Structure, Reconnaissance, Construction, and Rehabilitation

Railway structure is of strategic and tactical importance to the commander. Rail units are responsible for reconnaissance to determine the condition and characteristics of track, rolling stock, yards, terminals, shops, and other facilities. The highest unit headquarters determines requirements for rehabilitation and new construction after the original reconnaissance is made.

TRACK AND STRUCTURES

7-1. The track is the most important and most vulnerable part of a railway system. It usually crosses many miles of undefended territory. The track and structures are composed of many items designed to provide a smooth and strong riding surface for rail traffic.

COMPONENTS AND FUNCTIONS

7-2. Components and their relationships are described in the following paragraphs (see also Figure 7-l, page 7-2).

SUBBALLAST

7-3. Subballast consists of gravel, sand, or cinders, and it is inferior to ballast. Spread on the surface of the cut or fill, subballast provides a level surface for the ballast and other track components. It is spread about half the depth of the total ballast section and should never be less than 6 inches deep. Using subballast does the following:

- Saves higher quality stone for the ballast.
- Seals off contact between the ballast and the subgrade, which allows better drainage.
- Prevents indentation in the subgrade caused by ties under the weight of the train.

BALLAST

7-4. Ballast is gravel or broken stone laid on the ground to provide support for the track. The two types of ballast are mainline and yard ballast. Mainline ballast is larger in size (3/4" to 2" square) while yard ballast is smaller in size (3/8" to 1" square). Wooden, concrete, or steel crossties are laid across the ballast to support the rail. Tie plates and rail anchors are laid on the crossties. The rail is then secured to the crossties with spikes or screws. Sections of rail are then connected at the ends and the joints are bolted or welded to complete the track.

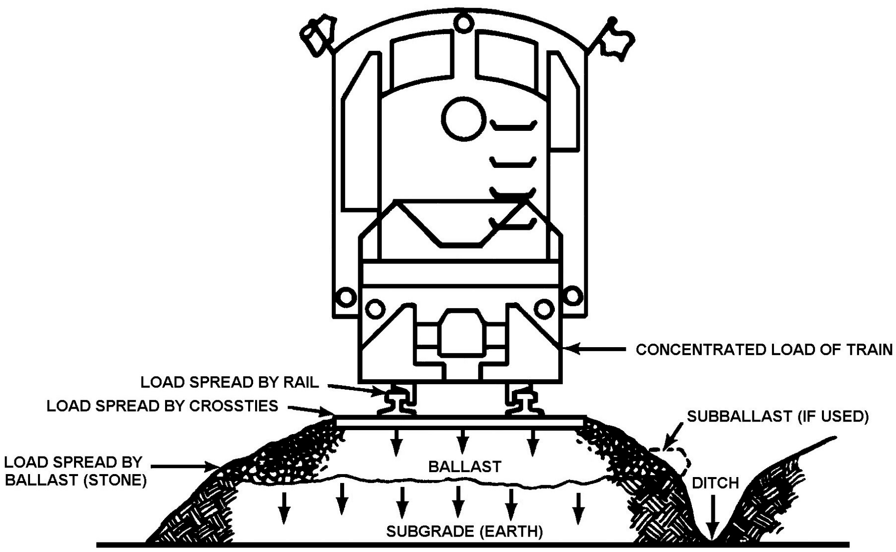


Figure 7-1. Main Components of a Railroad Track

7-5. Materials most commonly used as ballast are trap rock, granite, blast furnace slag, limestone, and graded gravel. For heavy tonnage and/or high speed traffic, broken or crushed stone is the most desired ballast. Blast furnace slag is almost as good as crushed rock. Ashpit cinders may also be used as ballast, but cinders are low in resistance to crushing. Other common but poorer ballast material are pit-run gravel, engine cinders, oyster shells, decomposed granite, and sand. However, sand may be used for light traffic lines. It is easily obtainable and drains reasonably well; but is difficult to tamp when dry, erodes easily from wind and rain, and collects dirt quickly. Ballast is usually locally available materials.

7-6. In order to perform its function, ballast must be resistant to water and weather, coarse for rapid drainage, fine enough to facilitate handling, and angular to resist movement. Using ballast does the following:

- Distributes the weight of the trains on the track.
- Keeps the track from moving under the weight of the trains.
- Provides adequate drainage for the track.
- Maintains proper track leveling and alignment.
- Retards growth of vegetation.

- Reduces dust.
- Distributes the load of the track and train to prevent overstressing the subgrade.
- Restrains the track laterally, longitudinally, and vertically under dynamic loads imposed by trains and thermal stress induced in the rails by changing temperatures.

CROSS AND SWITCH TIES

7-7. Crossties are currently used mainly on conventional track. Regardless of their shape, dimensions, or composition, crossties perform many functions necessary for an operational railroad track.

- The timber crosstie is used most often. The tie is cut from mixed softwoods and hardwoods and is treated with creosote, creosote-coal tar, or creosote petroleum solutions to prevent or retard fungi, bacteria, insects, borers, and decay. The treated timber tie varies in dimensions: 5" x 5" to 7" x 10" in cross sections, 8 feet to 9 feet in lengths for standard crossties, and 9 feet to 23 feet for switch ties and crossover ties. The standard US mainline crosstie (7" x 9" x 8'6") weighs approximately 250 pounds.
- The concrete crosstie has the same general dimensions as the timber crosstie, but is almost twice as heavy. Most concrete crossties have direct fixation fastenings with a cushioning pad between the tie and the rail base. These fastenings can be either a threaded type or a threadless type. In any of its forms, fastening is the weakest part of the concrete crosstie system.
- Steel crossties are tough, flexible, and resistant to mechanical deterioration. They are manufactured in a variety of shapes and include special features such as an integral fastening system. They are not normally found in trackage that has an electric current as part of a signal system or in an electrically powered railway system.

7-8. Crossties support vertical rail loads (train weight) and distribute those loads over a wider area of the supporting material (ballast). Crossties provide a smooth surface onto which the rail can be fastened, therefore resisting rail movements caused by train movement. Crossties also provide a means to fix and maintain the gauge (distance) between the rails.

7-9. Switch ties should always be made of hardwood. Switch ties are specially cut and formed crossties. Switch ties are designed mainly to support switches, switch stands, and the moveable rails of the switch.

RAIL

7-10. All parts of the track are essential. However, the rail is subjected to the greatest stresses and which is basic to the energy saving efficiency of railroads.

Construction

7-11. Rail steel contains iron, carbon, manganese, and silicone. Impurities sometimes found in steel are phosphorous, sulfur, and slag. Rail is identified by its weight per yard and its cross-sectional shape design. The rail weight is referred to as its nominal weight per yard or meter, such as 115 pounds per yard and 52 kilograms per meter. Rail can be manufactured in many different lengths. In the US, the standard lengths for rail are 39 feet and 78 feet. Lengths in other countries are similar.

Joints

7-12. Rail can be constructed into a track in two ways. It may be jointed (conventional construction) or welded (continuous welded rail).

7-13. In conventional construction, the 39-foot rail sections are joined together using bolts and joint bars. The 39-foot rail sections are welded together at central rail welding plants. One quarter-mile long strings are welded in place using the thermite welding process. Normally the only welds you find in 39-foot jointed rail are found at road crossings and bridges. For continuous welded rail, the ties are normally closer together and requires more and a better quality of ballast.

Rail Anchors

7-14. Rail anchors are installed on the rail base securely against the side of the tie. Anchors are designed to resistor check the longitudinal movement of the rails under traffic. They also maintain proper expansion and contraction forces that build up in continuous welded rail (Figure 7-2). Without anchorage, the rail will run irregularly. At locations where expansion forces concentrate, the track can buckle or warp out of line or surface. At locations where contraction forces concentrate, the field welds can be broken or the bolts can be sheared.

Tie Plates and Fastenings

7-15. Tie plates protect the wooden crosstie from damage under rails and distribute wheel loads over a larger area. They also hold the rail at the correct gauge, tilt the rail slightly inward to help counter the outward lateral weight of wheel loads, and provide more desirable positioning of the wheel bearing area on the rail head (Figure 7-3, page 7-6).

- **Application.** Tie plates are attached to the ties by spikes, screws, or other fasteners. Attachments are installed into the tie through the holes manufactured into the tie plate. Some of the spikes (or other fasteners) in each plate also hold the rails in the rail seat formed in the tie plate (Figure 7-4, page 7-6).

- **Functions.** There are three primary functions of any rail fastening system. These functions are as follows:
  - Transfers the wave motion of the rail (which precedes and follows a wheel) to the tie, which will cushion the shock.
  - Provides an anchoring force to help restrain longitudinal movement of the rail.
  - Holds the rail alignment, while still providing a slight vertical flexibility.

Track Spikes

7-16. Track spikes do the following:

- Holds the rails to the correct gauge and alignment.
- Prevents the rail from overturning.
- Secures tie plates to the ties.

Hook head or cut spikes are used extensively in CONUS and in military railroading. Screw spikes are used primarily in Europe. Four to eight spikes are used per tie. Use four spikes on straight track and eight spikes on curved track. Examples of each are shown in Figure 7-5, page 7-7.

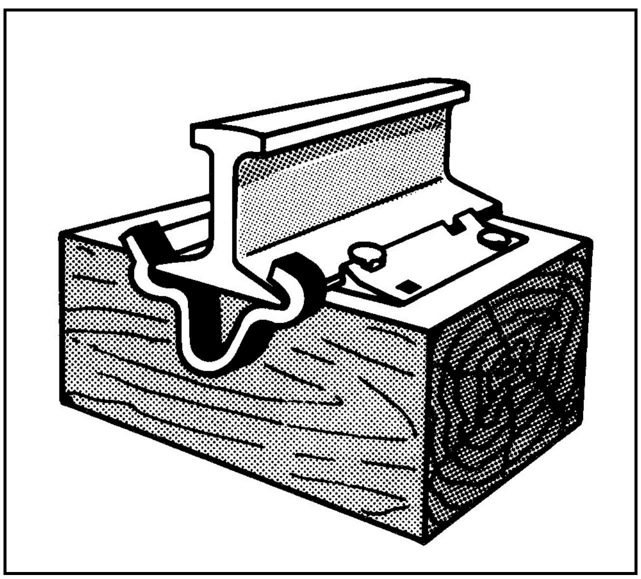


Figure 7-2. Simple Rail Anchor on Base of Rail

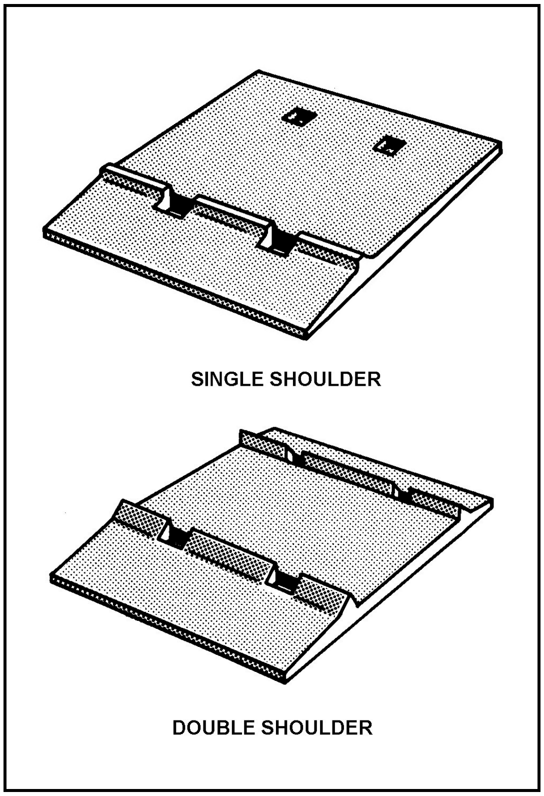


Figure 7-3. Tie Plates

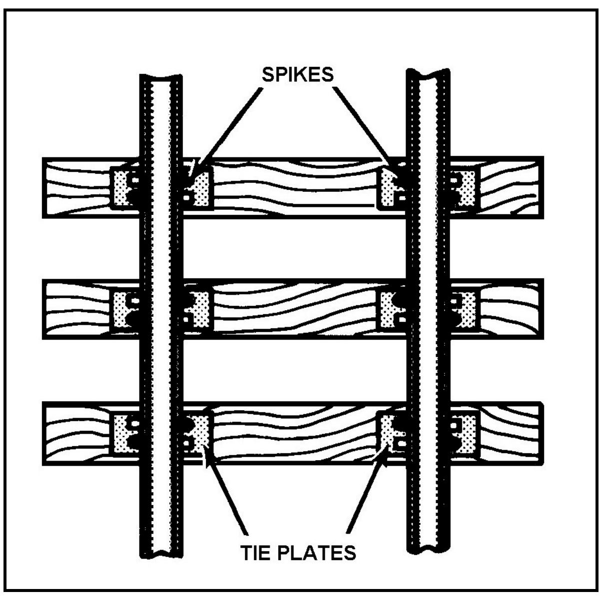


Figure 7-4. Correct Method of Setting Spikes

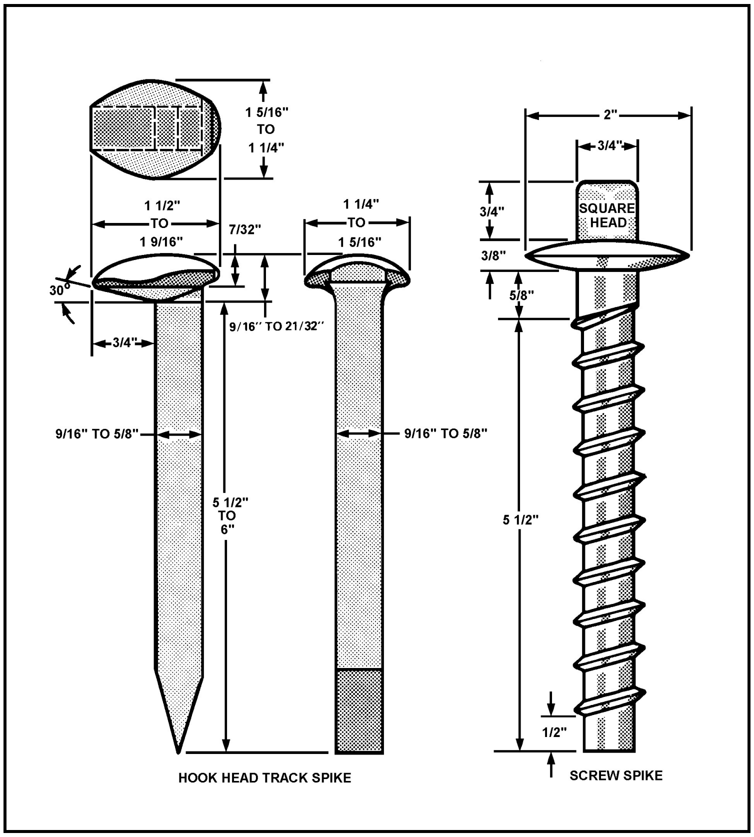


Figure 7-5. Spikes

Rail Joints and Accessories (Splice Bars)

7-17. Rails must be connected at the joints so that the rails will act as a continuous girder with uniform surface and alignment. Therefore, inspect all rail joints and accessories obtained from suppliers or storage before they are placed in track.

- **Functions.** The primary purpose of any rail joint is to maintain the fixed relationship of the abutting rail ends and to provide a structural means of transferring the wheel loads from one rail to another. If possible, the rail joint should have the same strength and stiffness as the rail. This can be done by using two steel members. They fit in the space on each side of the rail and span the gap between the two rails. These compromise angle bars are normally held in place by bolting (Figure 7-6, page 7-8).

- **Types.** The track bolt, spring (lock) washer, and nut are the most commonly used joint accessories. The track bolt is made from heat-treated, high-carbon steel. It has an elliptical neck under the bolt head which mates with a matching elliptical hole in the joint bar. This provides a means of holding the bolt during the tightening operation. These holes are normally alternated in the joint bar so that every other bolt is put through the assembly from the opposite side. This practice makes it extremely unlikely that all the bolts in a joint would be broken during a derailment.

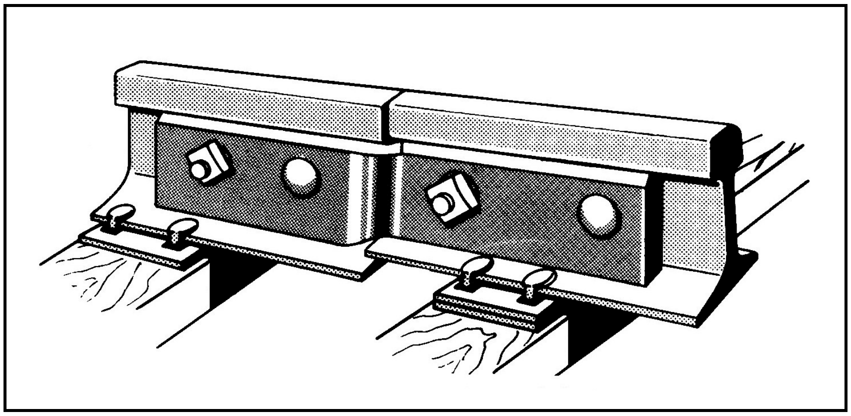


Figure 7-6. Compromise Angle Bar

SWITCHES

7-18. Switches are mechanical devices consisting of special crossties with rails that permit a train to change tracks and therefore, change direction. Switches may be controlled either manually or electronically.

7-19. Switches have left-hand and right-hand switch points that divert the rolling stock to the proper turnout. Switches also have one or more rods to hold the points in correct relationship to each other and to prevent them from rising. A gauge and switch plates support the switch points at the same elevation as the permanent rail and maintain the correct position of the switch. Clips unite the rods with the switch points and metal guards provide foot protection (Figure 7-7 and Figure 7-8).

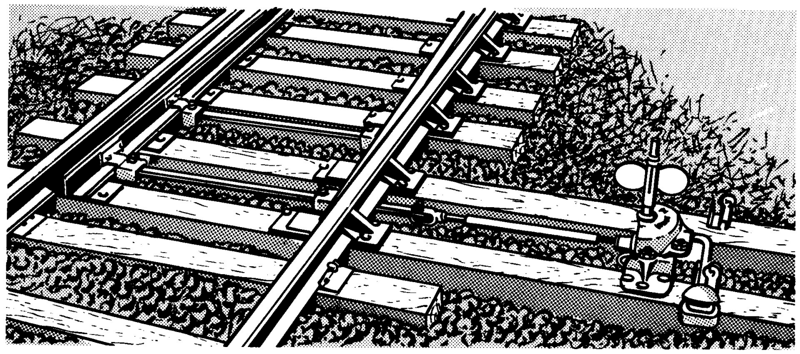


Figure 7-7. Manual Switch

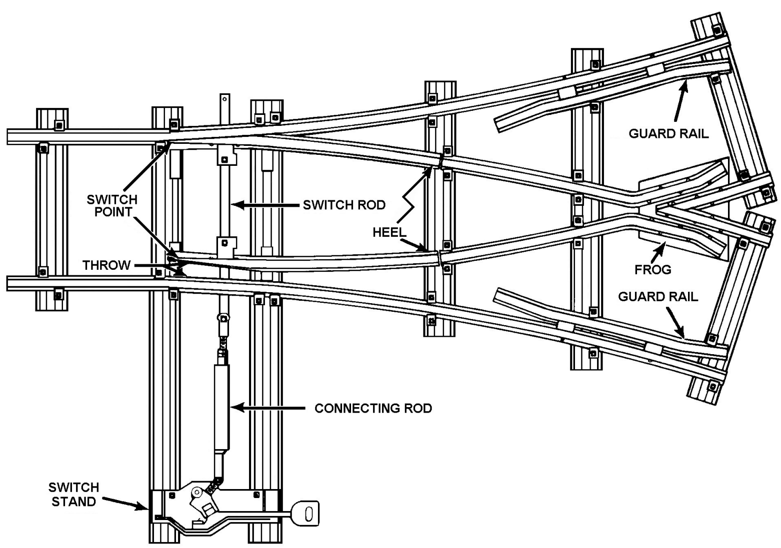


Figure 7-8. Switch Components

SWITCH STANDS

7-20. A switch stand is the mechanism which controls the operation of the switch. The stand also shows the switch's position. The following are the two types of switch stands.

- **Low stands (or ground throw stands).** In low stands or ground throw stands, the hand-throwing lever travels in a vertical plane.
- **High stands (or column-throw stands).** In high stands or column-throw stands, the throwing lever travels in a horizontal plane.

7-21. A switch stand consists essentially of a base, spindle, and throwing lever. These parts are assembled to form mechanisms which, by the use of cranks, gears, yokes, toggles, and other fittings, transmit the circular motion of the throw lever to a switch connecting rod. Therefore, the spindle and its associated mechanism are important parts of the switch assembly. The spindle and its associated mechanism multiplies force applied to the throw lever, delivering maximum force at critical positions in the throw. A switch stand is held in a fixed position, by the anchorage of its base to two ties (Figure 7-9).

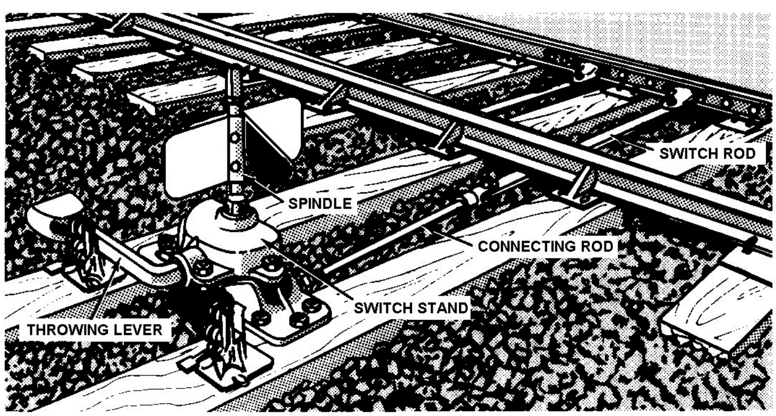
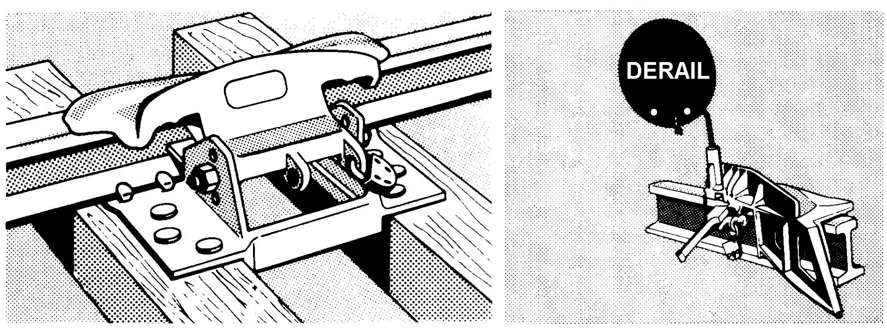


Figure 7-9. Switch Stand Assembly

DERAILS

7-22. Derails are safety devices designed to limit unauthorized movement of a car or locomotive beyond a specific point. The most frequent use of derails is to prevent unauthorized movement of equipment from a side track onto a main track. Derails are sometimes used to prevent the movement of equipment onto portions of a side track where it might cause an accident or damage.

7-23. Derails are also used to ensure that rules or signals are obeyed and to protect personnel and equipment against unauthorized, careless, or accidental procedures. If a train passes over an operating derail, the train will be derailed. Types of derails are shown in Figure 7-10.



HINGED DERAILER PORTABLE DERAILER

Figure 7-10. Derailers

FROGS AND GUARD RAILS

7-24. Frogs are special pieces of trackwork that enable flanged wheels to cross from one rail onto another rail. Guard rails consist of a rail or series of rails that lay parallel to the running rails of a track (also see Figure 7-11, page 7-12).

Frogs

7-25. Frogs provide continuous channels for the wheel flanges and support the wheels over the intersection. Frogs are built of carbon or heat-treated steel rails, of carbon steel rails combined with manganese steel casings, and of solid manganese casings. Frogs do not require any mechanical operation.

Guard Rails

7-26. Guard rails helps prevent derailments. They also hold wheels in alignment and keep derailed wheels on the ties.

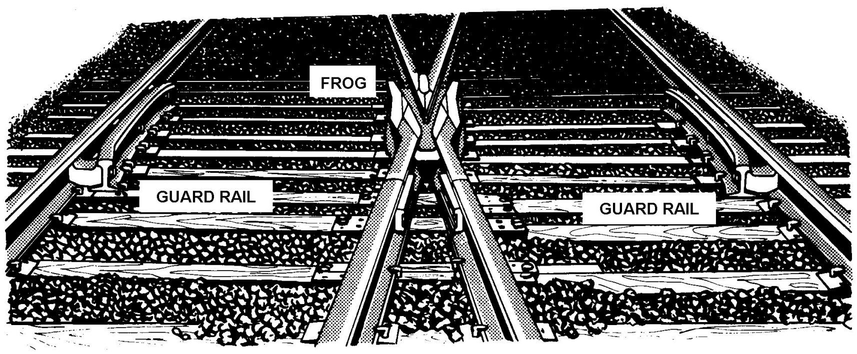


Figure 7-11. Frog and Guard Rails

7-27. There are three types of guard rails. Each type is described below.

- **Turnout guard rails.** These rails are designed and installed to prevent the flanges of the wheels from striking the points of the frogs on turnouts and crossovers.
- **Curve guard rails.** These rails are applied to sharp curves to guide the flanges of locomotive and car wheels or to support the blind driving wheels of locomotives.
- **Bridge guard rails.** These rails prevent derailed wheels from running off the ties on a trestle, bridge, or viaduct.

TRACK TOOLS

7-28. The mechanization of track maintenance equipment continually progresses in the variety of machines and equipment as well as the functions they perform. However, the basic tools designed for manual use are still required on all railroads. Such tools have a well-defined roll in specific work assignments. For example, mechanized equipment may not always be available to replace a defective rail or deteriorating ties, surface a rough spot, gauge a wide spot in a curve, replace a cracked joint bar, or effect other random maintenance tasks that can be done efficiently with a small work crew. However, there is new equipment currently being used by the railroad industry, which has greatly reduced the size of work crews and greatly increased productivity (Figure 7-12 and Figure 7-13).

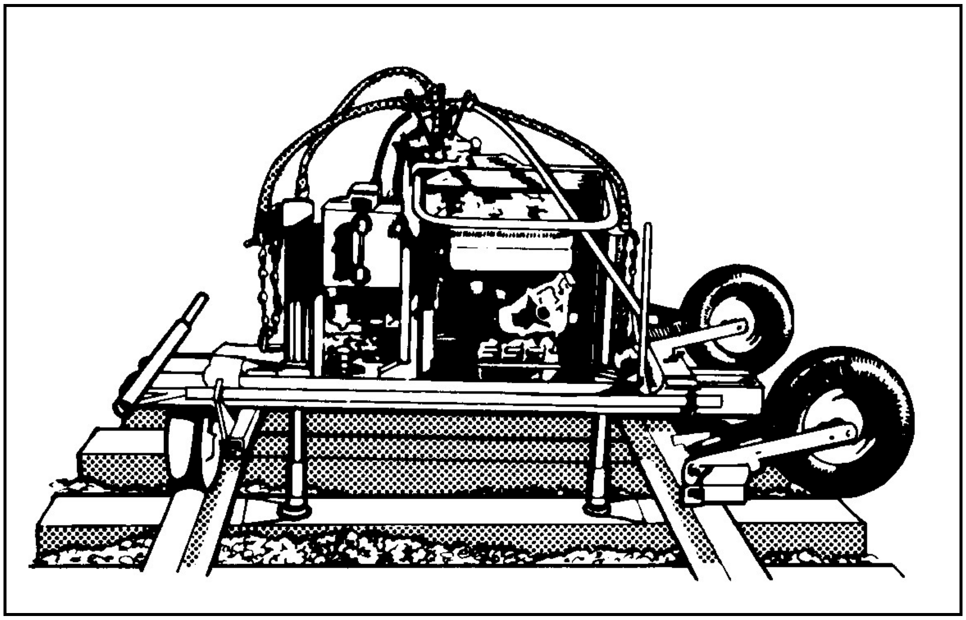


Figure 7-12. Automatic Rail Lifter/Trade Jack

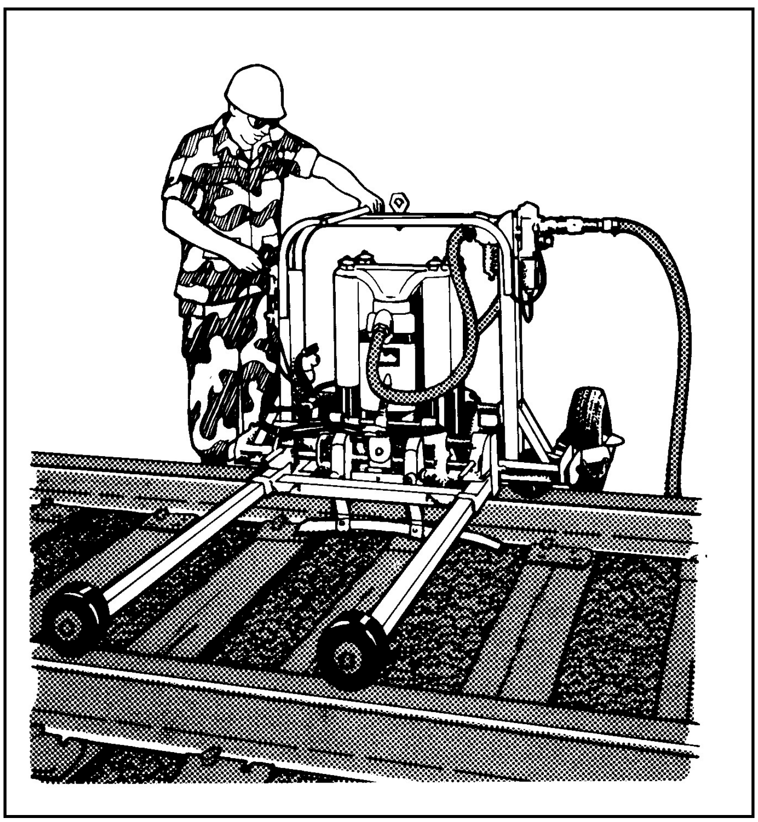


Figure 7-13. Spiker

EFFECTS OF TERRAIN ON TRACK ALIGNMENT AND PROFILE

7-29. The ideal railroad track would be on a flat terrain with no curves. Track routes are actually determined by acquisition of property, general terrain of a particular area, and locations that are served by the railroad. Other factors which determine military railroads are:

- Axis of advance.
- Main supply routes.
- Availability of existing lines and damage sustained to them.
- A unit's ability to defend the lines.

Trade-offs are made between repairing a railway to full operating capacity while neglecting others, and repairing multiple segments of lines to reduced capacity. It is almost always more important to rehabilitate a rail line so that it can operate at a reduced capacity (no signals, primitive operations, and so forth) than to hold all operations until the final spike is driven. In almost every case, trains will be operating while railroad rehabilitation and construction is taking place. Many times operations will continue over the very same track being repaired.

TRACK PROFILE

7-30. Track profile is the term applied to the vertical dimensions of the track caused by terrain features such as hills or valleys. Every attempt is made to reduce inclines or grades since they have a direct bearing on the amount of motive power needed to pull a train. From an operational point of view, boring a tunnel through a mountain may therefore be preferable to going around or over a mountain.

TRACK ALIGNMENT

7-31. Track alignment is the term applied to the horizontal dimension of a track (for example, curves). Curves are needed to change track direction, whether intentionally (route) or unintentionally (obstacles). The radius of the curve must be as large as possible, as curves apply rolling resistance to train movement. Since a train in motion tends to move in a straight line, it applies a lateral force against curves in the track and increases motive power requirements.

7-32. The alignment of a railroad consists of straight sections (tangents) connected by curved sections. The sharpness of a curve is measured in degrees, minutes, and seconds. Horizontal curves are classified as simple, compound, and reverse. A simple curve is a single arc connecting two tangents. A compound curve is formed by two simple curves of different radii, both curving in the same direction. A reverse curve consists of two curves that bend in opposite directions (Figure 7-14).

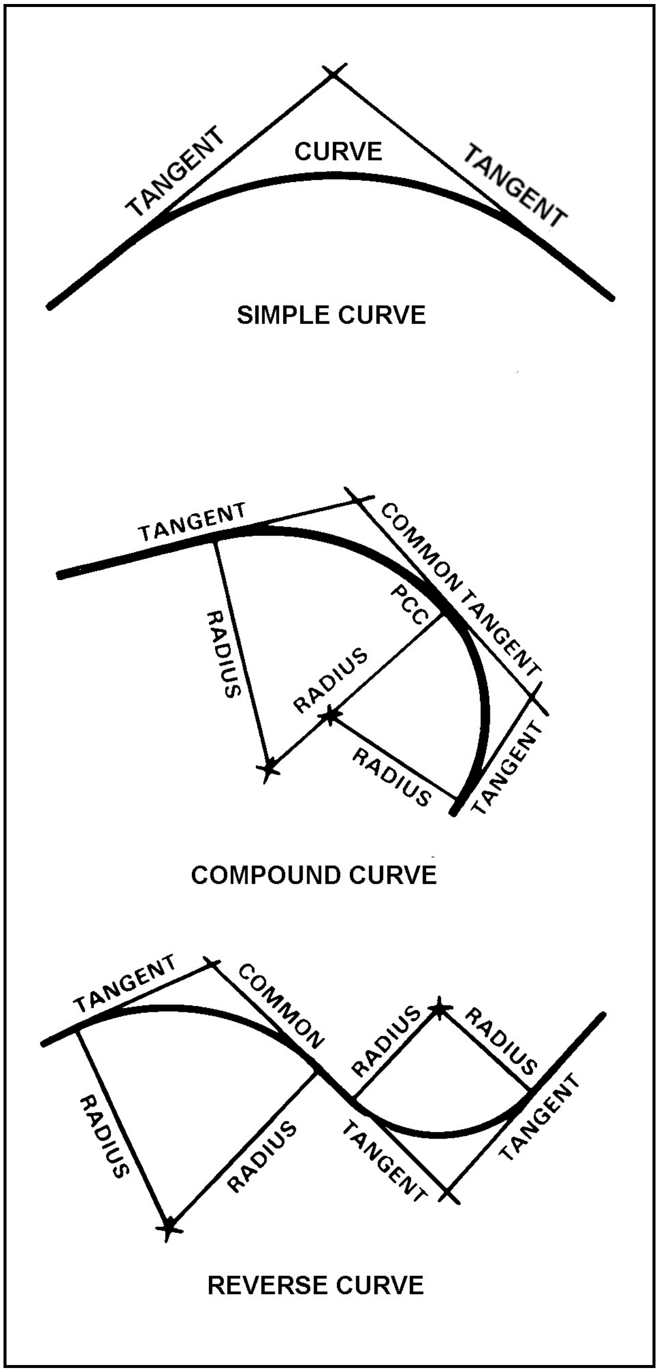


Figure 7-14. Types of Horizontal Curves

RULING GRADE

7-33. A key factor when calculating motive power requirements for a train is the ruling grade that will be encountered between the starting point and the final destination. The ruling grade calculation considers both track alignment and profile. The steepest grade might not be the ruling grade since another location with a lesser grade, but a tight curve, could cause more rolling resistance. The higher the rolling resistance, the more motive power is needed. Higher motive power for any one train is obtained either by using a more powerful locomotive or by using two or more locomotives.

7-34. Grade lines are designated by the vertical change in 100 feet (30 meters). A grade rising 2 feet in a horizontal distance of 100 feet is called a +2.0-percent grade; one descending the same amount is called a -2.0-percent grade. Any grade from 0.0 percent (or level) to 0.4 percent is called light; from 0.4 to 1.0 percent, moderate; from 1.0 to 2.0 percent, heavy; and above 2.0 percent, very heavy.

DETERMINING CURVATURE

7-35. Use either the survey method or string method to determine curvative. Each of these methods is described below.

Survey Method

7-36. When computing curvature, chord is measured as 100 feet (30 meters). Use the following formula to determine an approximate value for the radius. However, it is possible to obtain an approximate value for the radius from the following simple empirical formula:

$$R = \frac{5{,}730}{D}$$

D

Where—

R = Radius

D = Degree of curvature

5,730 ft (1,747 m) = approximate length of radius of a l-degree curve

Likewise, D can be computed by:

$$D = \frac{5{,}730}{R}$$

String Method

7-37. Use the string method to determine the approximate degree of curvature if a surveying instrument is not available. A portion well within the main body of the curve is selected; a chord distance of 62 feet (18.9 meters) is measured along the inside of the high rail (Figure 7-15, points A and B). A string or strong chord is stretched tightly between points A and B, and the distance M is measured at the midpoint of the chord. This distance, in inches, is approximately equal to the degree of curvature. As a curve gets sharper, this distance increases. The normal method of horizontal curve layout for railroads uses the string method.

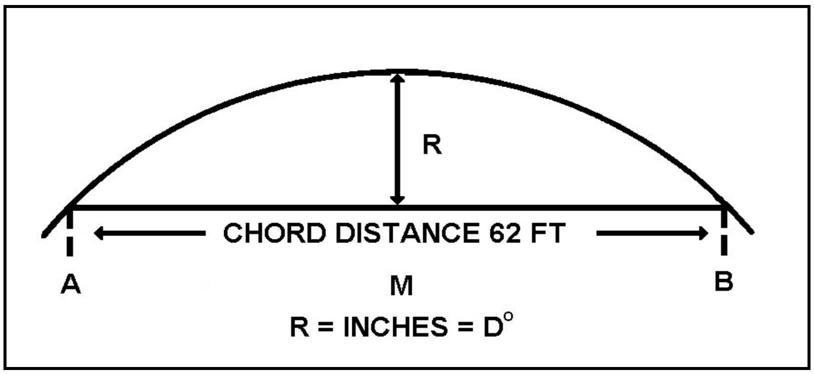


Figure 7-15. String Method

STRUCTURES

7-38. Structures can generally be divided into two classes. The two classes are minor structures or major structures. These two classes are described below.

MINOR STRUCTURES

7-39. Minor structures are provided to carry the track over minor natural features (such as small streams and ditches) or over man-made drainage features (such as pedestrian walkways and pipelines). Minor structures are mainly some form of pipe-like construction. These pipes can be of corrugated metal or reinforced concrete. They are generally open-ended and cross under the track at angles varying from 45 degrees to 90 degrees. These structures are vital to the long-term stability of the track and roadbed.

MAJOR STRUCTURES

7-40. Major structures are provided to carry the track over or through major natural or man-made features (such as over rivers or highways or through mountain tunnels). Major structures are usually considered to be bridges or trestles and tunnels.

Bridges

7-41. Bridges are normally constructed from steel, reinforced concrete, masonry, and timber. Two general types of bridges are ballast deck and open deck. A ballast deck bridge has a trough-like deck in which a layer of ballast can be laid. The track is constructed on the ballast using standard track construction techniques. The ballast deck bridge is excellent from the standpoint of fire prevention and track maintenance. This type also allows the use of normal track materials and maintenance procedures (Figure 7-16). An open deck trestle uses the bridge's ties as crossties for the track (Figure 7-17).

- **Bridge Capacity.** The design of bridges is to safely carry a specific concentrated load. Loads which may be placed on a structure temporarily or which may be changed in position are termed live loads to distinguish them from fixed, dead, or static loads. Live loads are the tonnage trains; static loads are the superstructure, tracks, ties, and so forth. The maximum live load consists of two coupled locomotives followed by the number of cars that occupy the entire length of the bridge. Although various formulas have been used to compute bridge capacity, the most accurate of these is Cooper's E rating. In this formula, each driving axle on the locomotive carries a proportionate part of the total weight loaded on the drivers. A bridge designed to carry a 0-6-6-0 diesel-electric locomotive weighing 240,000 pounds (108,844 kilograms) on the drivers, must have a Cooper's rating of at least E-40 (40 equals to 40,000 pounds). A 0-6-6-0 locomotive has six driving axles. The following is the formula for computing the E rating of the locomotive:

  240,000 pounds = 40,000 pounds

  6 (driving axles)

  or

  108,844 kilograms = 18,144 kilograms

  6 (driving axles)

  = the amount each axle can carry

If the gross weight of a car in the train exceeds the weight of the locomotive pulling the train, then the Cooper's E rating must be computed based on the gross weight of that car. The E rating must be for the heaviest piece of rolling stock in the train.

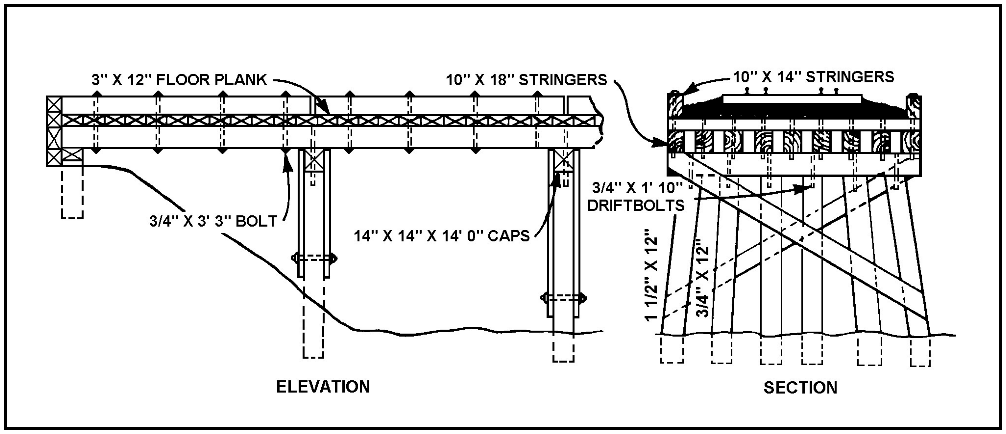


Figure 7-16. Ballast Deck Bridge

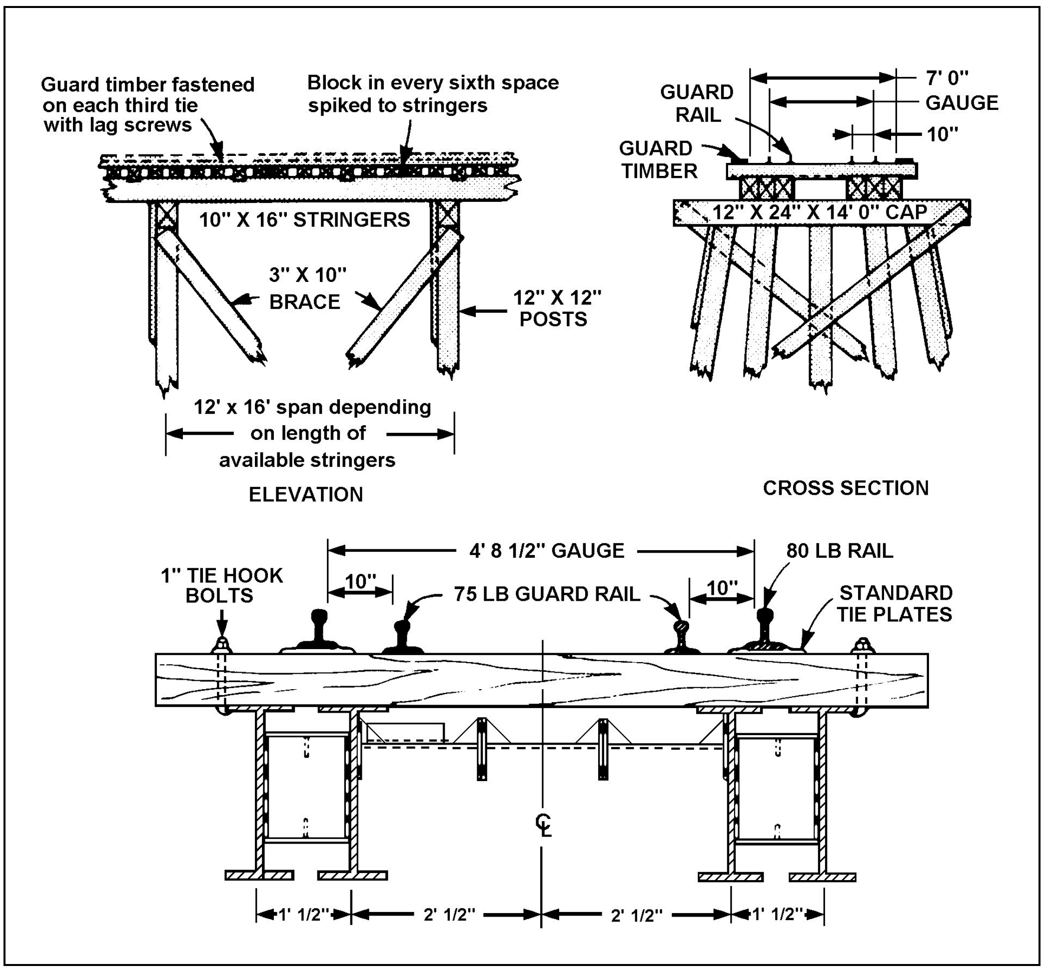


Figure 7-17. Open Deck Bridge

- **Steel and Wooden Stringer Bridges.** There usually is an economical consistency in the design of all parts of a railroad bridge. Dimensions of the floor system are related to the load for which the whole structure was designed. Table 7-1 and Table 7-2, page 7-22, show the Cooper's E rating of a number of typical railroad bridges and the stringer dimensions of their floor systems.
  - To estimate the capacity of a railroad bridge with steel stringers or girders as part of the floor system, the width and thickness of the lower flange of the stringer are measured (Figure 7-18, page 7-23). The depth and the length of the stringer are also measured. The corresponding E rating of the bridge is then determined from Table 7-1.
  - To estimate the capacity of a railroad bridge with wooden stringers as part of the floor system, the width of each stringer under one track is measured. The widths of all the stringers are then added together to attain the total (Figure 7-19, page 7-23). The depth and length of one stringer also are measured. From Table 7-2, the wooden stringer is selected that most nearly approximates these dimensions and the corresponding E rating of the bridge is determined.

Tunnels

7-42. Two principal types of tunnels are lined and unlined. Lined tunnels are cut through unconsolidated formations. A lining is provided to prevent cave-in on these types of tunnels. These linings are usually formed from concrete or timber. Unlined tunnels are cut through solid rock formations. The rock walls and ceiling that remain, form the exposed surfaces of the tunnel.

EFFECTS OF COLD WEATHER

7-43. Cold weather conditions can impose a considerable burden on the operation and maintenance of railway service. Cold weather can effect yard switching (making it slow and difficult). It also has an effect on starting trains and making steel car parts brittle. Heavy winds (common in cold weather) can also hamper operations on the road and in the yards.

TRACK AND ROADBED

7-44. In cold climates, having a terrain similar to that of Alaska, the elements may cause damage to the track and roadbed. Areas of this type are underlaid with permafrost through which surface water cannot penetrate and which drains off in the summer. During thaws, the water lies on top of the ground, often partially covering the ties. This can cause tie rot and disturbs alignment, surface, and gauge. In winter, the water freezes and heaves the track dangerously out of line. Maintenance must be done on the track and roadbed as soon as the weather permits.

Table 7-1. Determination of Bridge Capacity (Steel I-beam Construction) (Cooper's E Rating)

Stringer Dimensions (in)			Span Length (ft)											
Thickness	Width	Depth	10	11	12	13	14	15	16	17	18	19	20	22
3/8	8 3/8	18	E-42	E-41	E-41	E-41								
3/8	10 3/8	24		E-59	E-48	E-40	E-35	E-31	E-27					
1/2	10 3/8	30				E-61	E-59	E-51	E-46	E-41	E-37	E-33	E-30	E-27
1/2	12 1/2	30						E-62	E-56	E-50	E-45	E-41	E-37	E-31
1	14	36								E-60	E-58	E-55	E-54	E-51
1/2	12 3/8	42										E-60	E-54	E-45
1 1/8	14	42											E-63	E-60

Stringer Dimensions (in)			Span Length (ft)										
Thickness	Width	Depth	24	26	28	30	35	40	44	50	54	60	64
1/2	12 1/2	30	E-26										
1	14	36	E-48	E-43	E-39	E-34	E-26						
1/2	12 3/8	42	E-39	E-34	E-30	E-26							
1 1/8	14	42	E-57	E54	E-51	E-45							
1 1/8	16	42			E-60	E-54	E-42	E-32					
1 1/2	16	48				E-59	E-52	E-47	E-43	E-33			
1					E-66	E-57	E-45	E-35	E-30				
1 5/8	14	54					E-54	E-43	E-36	E-28			
1 3/4	14	60						E-60	E-54	E-43	E-37	E-30	E-27

Stringer Dimensions (in)			Span Length (ft)										
Thickness	Width	Depth	40	44	50	54	60	64	70	74	80	84	90
1 1/2	14	60	E-57	E-48	E-38	E-33	E-27						
2 1/8	15	66			E-57	E-54	E-46	E-41	E-34	E-31	E-26		
2	14	66			E-56	E-48	E-40	E-35	E-30	E-26			
2	14	72			E-62	E-54	E-44	E-39	E-32	E-29	E-25		
2 1/2	15 1/2	72					E-55	E-51	E-43	E-38	E-33	E-29	
2 1/8	14	78				E-64	E-52	E-46	E-39	E-35	E-30		
2 1/2	16	84						E-64	E-54	E-49	E-41	E-38	E-30
2 11/16	20	96										E-59	E-51

Table 7-2. Determination of Bridge Capacity (Wood Beam Construction) (Cooper's E Rating)

Stringer Dimensions (in)		Span Length (ft)						
Thickness	Width	10	12	14	16	18	20	22
18	12	E-16	E-12					
18	14	E-22	E-18	E-10				
18	16	E-28	E-20	E-15	E-10			
18	18	E-38	E-26	E-18	E-14	E-12		
20	12	E-18	E-12					
20	14	E-25	E-17	E-12				
20	16	E-33	E-23	E-16	E-12	E-10		
20	18	E-43	E-29	E-21	E-16	E-13	E-10	
24	12	E-22	E-15	E-11				
24	14	E-30	E-21	E-14	E-11			
24	16	E-40	E-28	E-20	E-15	E-12		
24	18	E-52	E-36	E-25	E-19	E-15	E-12	E-10
36	12	E-34	E-23	E-17	E-12	E-10		
36	14	E-47	E-32	E-23	E-17	E-14	E-11	
36	16	E-62	E-43	E-30	E-23	E-19	E-15	
36	18	E-78	E-53	E-30	E-30	E-24	E-20	E-16
40	12	E-38	E-26	E-19	E-14	E-11		
40	14	E-52	E-36	E-26	E-20	E-16	E-12	
40	16	E-69	E-47	E-35	E-26	E-21	E-17	E-17
40	18	E-87	E-60	E-44	E-34	E-27	E-22	E-18
48	12	E-46	E-31	E-23	E-17	E-13		
48	14	E-63	E-43	E-31	E-24	E-19	E-15	
48	16	E-69	E-47	E-35	E-26	E-21	E-17	E-17
48	18	E-105	E-73	E-53	E-41	E-33	E-27	E-22
54	12	E-52	E-35	E-27	E-19	E-15		
54	14	E-72	E-49	E-35	E-22	E-18		
54	16	E-94	E-65	E-46	E-36	E-29	E-24	
54	18	E-119	E-42	E-60	E-46	E-38	E-30	E-25
60	12	E-58	E-40	E-30	E-22	E-17		
60	14	E-79	E-55	E-39	E-30	E-35	E-20	
60	16	E-104	E-72	E-52	E-40	E-33	E-27	
60	18	E-132	E-92	E-67	E-52	E-42	E-34	E-28

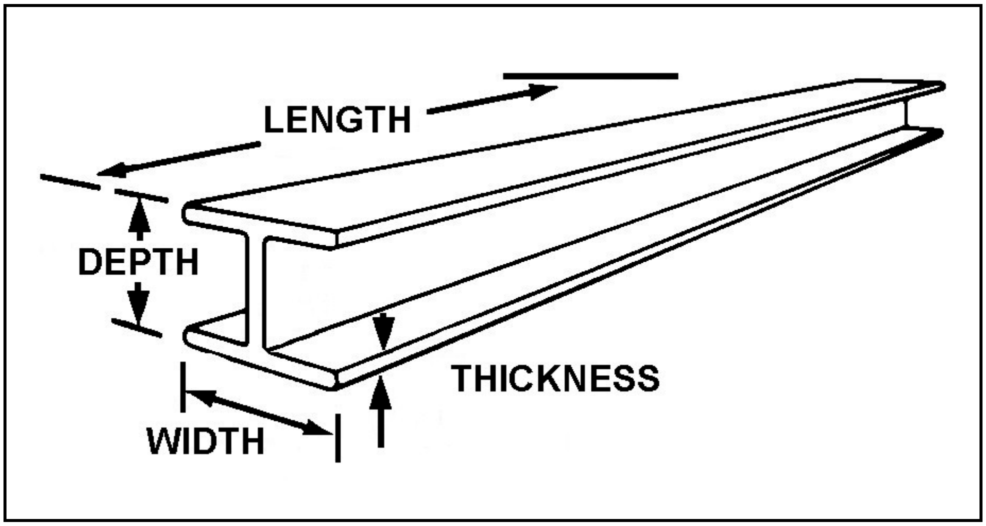


Figure 7-18. Dimensions of a Steel Stringer

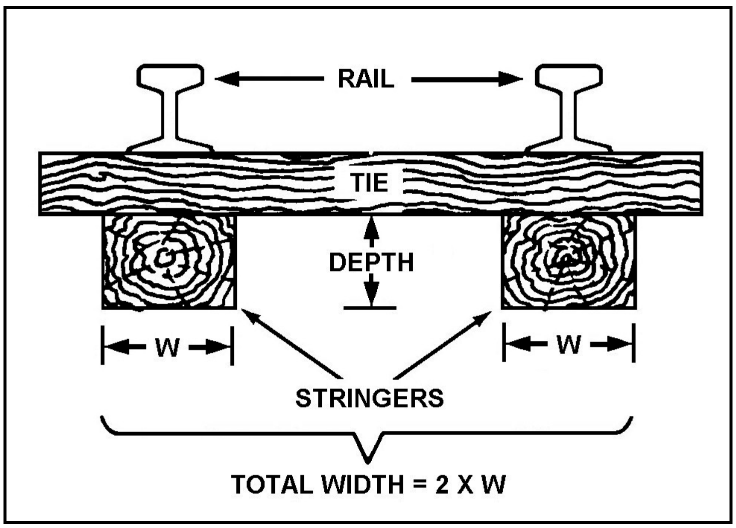


Figure 7-19. Dimensions of a Wooden Stringer

BRIDGES

7-45. Frost-heaving causes extensive maintenance repair to be made on bridges and trestles constructed of wood pilings. These repairs may reduce division train density. Maintenance problems occur when water below the ground surface freezes, therefore causing the piling to rise. This in turn may raise the level of a bridge 2 or 3 inches higher than the normal level of the track. There is no known way to combat this condition except by removing the decking, track, and ties; cutting off the tops of the piling to a suitable height; and then replacing the top structure.

POLE LINES

7-46. In some areas it may be impossible to use telegraph or utility poles in the conventional manner. In warm weather, the soil in low spots becomes so unstable that the poles cannot be kept vertical. In winter, the poles may be heaved up by frost and the wires will break. Wires should never be too taut between poles because winter contraction may cause them to break. Using poles built in a tripod shape with a wide base that rests on the ground will help stabilize the poles. Nothing can be done about wires that break due to heavy ice covering. An adequate supply of wire and splicing materials and maintenance personnel must be available to keep communication functions open during the winter.

TUNNELS

7-47. Tunnels are usually a simple maintenance problem. However, in cold climates, water seepage can cause extreme difficulties. Ice can form on the track, which often makes the tunnel impassable. There is hardly any way to bypass tunnels. In summer, the frozen earth under the track heaves to the extent that train movements may often be suspended. Work inside tunnels is slow and difficult because of the confined space in which men and machinery must work. In some areas, much of the difficulty has been overcome by steam heating some of the tunnels and putting doors on the portals. Workmen are assigned throughout the winter as firemen and door tenders to keep the tunnels warm and to open and close the tunnel doors for train passage. The tunnels are therefore kept at a temperature above freezing, and the water that seeps through the walls and ceiling is drained to the outside.

TRACK OBSTRUCTIONS

7-48. There are some obstructions that are either unforeseen or that anyone is able to control. Some of these are discussed below.

SNOWFALLS

7-49. Heavy and frequent snowfalls require the constant use of snowplows. During heavy snows, a locomotive with a plow may have to precede each main line train. At times, the snowfall may be so heavy that two trains may have to remain in sight of each other. It may be practical to equip locomotives with a small blade permanently attached to their pilots. Alaskan railroads have successfully used a notch blade that can be lowered a couple of inches below rail level. This is an expedient, which is only effective against snow a few inches deep. A snowplow, pushed by one or more locomotives, is usually needed to clear overnight snowfalls or even snowfalls of a few hours duration.

EARTH AND ROCK SLIDES

7-50. Slides are a frequent source of trouble in a hilly, cold climate. They occur in deep cuts, along steep slopes, and frequently at the mouths of tunnels when frozen hillsides or mountainsides thaw in the spring. In Alaska, and similar climatic and topographical areas, the summer shifting of glacial mountains is a problem. Glacial mountains move several feet each year over a lineal distance of several hundred yards. When a rail line runs alongside a glacial mountain, the affected right-of-way may have to be rebuilt. However, there is little that can be done if moving the track is not feasible. Prudent planning includes storing materials, tools, and supplies where they are in no danger of being covered by slides. Snow slides also present a serious problem in heavy snow climates. Such slides are generally heavier in weight and greater in volume than in temperate climate areas. Off-track machinery is not practical in cleanup operations because roads to reach such areas are usually nonexistent. The extreme cold also hampers workmen. The use of high-speed rotary snowplows in cleaning such slides is usually impossible because of the debris (for example; dirt, rocks, and twigs) that may come in contact with its high-speed blades.

WILD ANIMALS

7-51. The presence of wild animals on the track may cause temporary track obstructions and account for major delays to freight and passenger trains. Animals may get on snow-cleared tracks and remain there to escape the deep snow and because they have more of a chance to fight off other animals. All reasonable efforts must be made to clear animals unharmed from the track. For example, many moose have been killed on railroad tracks in Alaska, and trains running squarely over moose have been derailed. There are recorded cases where moose walked ahead of trains for 15 miles before leaving the track. During the rutting season, the bulls are extremely excitable and often charge a moving train. Railroad personnel working under such conditions must exercise care.

CONSTRUCTION AND REHABILITATION REQUIREMENTS

7-52. Table 7-3 lists the materials and net man-hours required for new construction of one mile of standard-gauge, single-track railroad. Table 7-4 estimates the requirements for rehabilitating a 100-mile standard-gauge, single-track division extending inland from a port using average percentage of demolition over the entire division.

Table 7-3. Construction Requirements Per Mile Standard-Gauge Single-Track Railroad

ITEM	STONs	MTONs	MAN-HOURS
Grading (includes clearing average wooded terrain)	-	-	5,000
Ballast delivered, average haul--5 miles (8.05 km)	-	-	2,500
Tracklaying and surfacing	-	-	3,400
Bridging--70 linear feet (21.34 m)	128	111	3,200
Culverts, 7 per mile--280 feet (85.34 m)	8	7	1,400
Ties--2,900	218	300	-
Rail, 90-pound--ARA--A Section	79	45	-
115-pound--ARA--E Section	103	57	-
Fastening (based on 39-foot rail) (11.89 m)	33	10	-
Total	569	530	15,500

Table 7-4. Rehabilitation Requirements Per Railroad Division

Item	Per 100 Miles (161 km)	Percent of Demolition	Rehabilitation (quantity)	Construction STONs	Material[1] MTs	Man-Hours[1] (Thousands)
Main line trackage	100 mi	10	7.0 mi	2,708	1,033	36.4
Port trackage[2]	-	100	3.0 mi	1,368	1,092	14.4
Passing sidings[2]	2.4 mi	80	2.4 mi	1,049	874	11.5
Station sidings[2]	1.6 mi	80	1.6 mi	730	582	7.7
Railway terminal[2,3]	1.0 ea	75	0.75 ea	8,025	4,875	160.0
Water stations	3.0 ea	100	3.00 ea	135	210	9.0
Fuel stations	1.0 ea	100	1.00 ea	19	16	0.9
Bridging (70 ft per mile)	7,000	55	2,700 linear ft	2,700	2,672	70.0
Culverts	28,000 linear ft	15	4,200 linear ft (74 ea)	63	63	13.7
Grading and ballast	-	-	-	-	-	40.5

[1] Tunnels require special consideration. To repair (by timbering) a 50-foot demolition at each end of a single-track tunnel (100 ft total per tunnel), allow 70 STONs or 87 MTs, and 3,000 man-hours.

[2] Estimate includes ties, rails, fastenings, turnouts, tracklaying, and surfacing. It is assumed ballast is available at work sites.

[3] Includes replacing buildings 100 percent, ties 30 percent, rail and turnouts 85 percent.